Nov 2020

1. With reference to ship's side valves:

 (a) state why grey cast iron is not a suitable material; (3)

 (b) state, with reasons, TWO suitable materials; (2)

 (c) state the regular maintenance that the valves should receive, outlining reasons for this maintenance. (5)

Question 1. The question specifically refers to ship side valves, many give answers based on general properties of cast iron in sea water.

Nov 2020

2. (a) Describe, with the aid of sketches, the operating principles of a centrifugal pump. (7)

 (b) State why centrifugal pumps are not self-priming. (3)

Question 2. Poor. Most mention kinetic energy but very few seem to know where the fluid gets the KE from. Nearly all state what priming is but fail to explain why a centrifugal pump is not self-priming, just stating that it can't displace air.

Nov 2020

3. (a) Explain the circumstances under which EACH of the following devices fitted to an air compressor may operate;

 (i) fusible plug; (4)

 (ii) bursting disc. (4)

 (b) State where EACH device in part (a) may be fitted. (2)

Question 3. Although the question asks about air compressors, many answer concerning fusible plugs on receivers. Few actually give the consequences of the devices not being present / not operating.

Nov 2020

4. With reference to hydraulic systems:

 (a) state THREE possible contaminations; (3)

 (b) state possible causes of the contaminations stated in part (a). (3)

 (c) explain how the contaminants stated in part (a) are prevented from affecting the system. (4)

Question 4. Well answered by most.

Nov 2020

5. Describe, with the aid of a block diagram, the operation of an automatic steering system, including auto-pilot and valve operated steering gear. (10)

Question 5. Very poor. Many do not understand the term 'block diagram', many simply sketch and describe a steering gear. Of those that try to describe the basics of control, they appear to believe that the rudder angle is fed back to the auto-pilot – i.e that the rudder has a set angle required to maintain the vessel on course rather than the rudder moving from centre to return the vessel to the set course. Rudder feedback is used to limit the rate of change of course but none mention this. Several make no attempt.

Nov 2020

6. With reference to controllable pitch propellers:

   (a) describe a mechanism that changes the pitch of the blades; (7)

   (b) explain how the pitch of the blades is indicated. (3)

Question 6. Several answer this question by describing the whole system, the question just asks about the mechanism for changing the blade angle. Of those that describe the mechanism, most mention longitudinal movement and angular but none actually explain how longitudinal is changed to angular. Several make no attempt

Nov 2020

7. With reference to intermediate shaft bearings of the roller type, describe, with the aid of a sketch, EACH of the following:

   (a) how some angular misalignment of the shaft is accommodated; (5)

   (b) how longitudinal movement of the shaft is accommodated. (5)

Question 7. Most are OK with angular movement but struggle to explain how longitudinal movement is allowed. Some explain thrust bearings, several make no attempt.

Nov 2020

8. Sketch an arrangement for the aft seal of an oil lubricated stern tube bearing. (10)

Question 8. Either well answered or no idea – drawing a sort of stern seal oil system. Several make no attempt.

Nov 2020

9. (a) State FIVE devices fitted to a main distribution switchboard in order to protect a.c. generators that can be operated in single or parallel mode. (5)

   (b) Explain why EACH device stated is needed. (5)

Question 9. The question asks about devices for protection of generators, many include pref trip and other devices that are for protection of distribution. Most, when answering about the reason for a device, simply state what it does – i.e over-current protection protects against overcurrent. The question is asking for the reason for the device – i.e what would overcurrent do to the generator.

Nov 2020

10. (a) Explain the term *single phasing*. (2)

    (b) State the effects on a motor of single phasing. (6)

    (c) State how single phasing may be protected against in the motor starter circuit. (2)

Question 10. Reasonably well answered by most, nearly all struggle with protection should single phasing occur.

Nov 2020

1. With reference to ship's side valves:

(a) state why grey cast iron is not a suitable material; (3)

(b) state, with reasons, TWO suitable materials; (2)

(c) state the regular maintenance that the valves should receive, outlining reasons for this maintenance. (5)

Question 1. The question specifically refers to ship side valves, many give answers based on general properties of cast iron in sea water.

Ship's Side Valve Materials and Maintenance

(a) Why Grey Cast Iron is Unsuitable:

Grey cast iron is not a suitable material for ship's side valves due to several drawbacks:

- **Brittle Fracture:** This type of iron has low tensile strength and can crack or shatter under sudden impact or excessive stress. Ship's side valves are exposed to wave action and external pressure, making them susceptible to such stresses.
- **Corrosion Susceptibility:** Grey cast iron is prone to rust and corrosion in saltwater environments, which can weaken the valve body and lead to leaks or even catastrophic failure.

(b) Suitable Materials for Ship's Side Valves:

1. **Cast Steel:**
- **Reasons:**
  - **High Strength:** Cast steel offers superior strength and ductility compared to grey cast iron. It can withstand high pressures and impact loads encountered by ship's side valves.
  - **Corrosion Resistance:** Certain grades of cast steel, particularly those with higher chromium content, exhibit good corrosion resistance in saltwater environments, ensuring valve longevity.
2. **Ductile Iron (Nodular Iron):**
- **Reasons:**
  - **Strength and Ductility:** Ductile iron offers a good balance between strength and ductility. It's stronger than grey cast iron and less brittle, making it more resistant to impacts and pressure fluctuations.
  - **Corrosion Resistance:** Similar to some cast steel grades, certain types of ductile iron have improved corrosion resistance suitable for seawater applications.

(c) Regular Maintenance for Ship's Side Valves:

Regular maintenance is crucial for ensuring the safe and reliable operation of ship's side valves. Here are some key maintenance tasks and their reasons:

- **Visual Inspection:** Regularly checking for cracks, corrosion, leaks, or damage to the valve body, bonnet, and external components helps identify potential issues before they escalate.

- **Gland Packing Replacement:** Over time, the packing material around the valve stem can wear and lose its sealing effectiveness. Replacing worn packing ensures a tight seal and prevents leaks.
- **Operational Testing:** Periodically operating the valve through its full open-close cycle verifies smooth movement and confirms the valve can be fully opened and closed when needed.
- **Lubrication:** Lubrication of moving parts (e.g., spindle threads) minimizes friction and ensures smooth operation during valve actuation.
- **Internal Cleaning:** In some cases, internal cleaning may be necessary to remove debris or buildup that could hinder valve operation or cause leaks.

By performing these maintenance tasks regularly, ship crews can ensure the continued reliability and safety of ship's side valves, minimizing the risk of failures and potential environmental damage.

2020

Nov 2020

2. (a) Describe, with the aid of sketches, the operating principles of a centrifugal pump. (7)

(b) State why centrifugal pumps are not self-priming. (3)

Question 2. Poor. Most mention kinetic energy but very few seem to know where the fluid gets the KE from. Nearly all state what priming is but fail to explain why a centrifugal pump is not self-priming, just stating that it can't displace air.

Centrifugal Pump Operation and Priming

(a) Operating Principles of a Centrifugal Pump:

Centrifugal pumps utilize the principle of rotary motion to convert mechanical energy into energy of fluid flow. Here's a breakdown of the key aspects:

1. **Components:**
    - **Impeller:** A rotating disc with curved vanes housed within a volute casing.
    - **Volute Casing:** A spiral-shaped chamber that surrounds the impeller and collects the pressurized fluid.
    - **Inlet Port:** The opening where fluid enters the pump casing.
    - **Outlet Port:** The opening where pressurized fluid exits the volute casing.
2. **Rotation:** The impeller is driven by a shaft connected to a motor or engine. As the impeller rotates, it spins the fluid within the casing.
3. **Centrifugal Force:** The rotation of the impeller imparts centrifugal force on the fluid particles. This force pushes the fluid outwards from the center of the impeller towards the periphery of the casing.
4. **Pressure Increase:** The volute casing design progressively converts the kinetic energy of the high-velocity fluid exiting the impeller vanes into pressure energy. The decreasing volume of the volute as it spirals outwards further contributes to the pressure rise.
5. **Discharge:** The high-pressure fluid is channeled through the volute casing and exits the pump through the outlet port.

6. **Continuous Flow:** As fluid is continuously discharged from the pump, a low-pressure zone is created at the inlet port. This pressure difference draws more fluid into the pump casing from the suction source, maintaining a continuous flow.

(b) Why Centrifugal Pumps are Not Self-Priming:

Centrifugal pumps are not self-priming for two main reasons:

1. **Air Pockets and Cavitation:** Centrifugal pumps rely on the presence of liquid within the casing to function effectively. Air pockets within the pump can hinder the transfer of centrifugal force to the fluid. Additionally, air pockets can cause cavitation, a phenomenon where the pressure drops below the vapor pressure of the liquid, leading to the formation and collapse of vapor bubbles that can damage the pump impeller.
2. **Need for Initial Pressure Difference:** For the centrifugal force principle to work, there needs to be a pressure difference between the inlet and outlet of the pump. A centrifugal pump cannot create a vacuum to draw in liquid on its own. Therefore, the pump casing and suction line must be initially filled with liquid to establish this pressure difference and enable the pump to operate efficiently.

2020

Nov 2020

3. (a) Explain the circumstances under which EACH of the following devices fitted to an air compressor may operate;

(i) fusible plug; (4)

(ii) bursting disc. (4)

(b) State where EACH device in part (a) may be fitted. (2)

Question 3. Although the question asks about air compressors, many answer concerning fusible plugs on receivers. Few actually give the consequences of the devices not being present / not operating.

Safety Devices in Air Compressors and Their Operation

(a) Circumstances of Operation:

(i) Fusible Plug:

A fusible plug is a safety device that melts and releases compressed air when the temperature inside the air compressor exceeds a predetermined safe limit. This typically occurs under the following circumstances:

- **Internal Component Failure:** If a component within the compressor, such as bearings or pistons, seizes or malfunctions, it can generate excessive heat. This heat can melt the fusible plug, releasing pressure and preventing catastrophic failure of the compressor itself.
- **Loss of Cooling:** If the compressor's cooling system fails, such as due to a water pump malfunction or clogged radiator, the internal temperature can rise significantly. A melted fusible plug would then vent the pressure before overheating damages the compressor.
- **Accidental Overheating:** In rare cases, operator error or external factors might lead to overheating of the compressor. A fusible plug can act as a last line of defense by releasing pressure and potentially preventing an explosion.

(ii) Bursting Disc:

A bursting disc is a pressure relief device that ruptures and releases compressed air when the pressure inside the air compressor or its associated piping exceeds a predetermined safe limit. This typically occurs under the following circumstances:

- **Pressure Regulator Failure:** If the pressure regulator malfunctions and fails to maintain the desired pressure level, the pressure within the system can continue to rise. A bursting disc would then rupture to prevent the system from exceeding its pressure rating and potentially rupturing pipes or equipment.
- **Blocked Discharge Line:** If the discharge line from the compressor becomes blocked due to debris or ice buildup, the pressure within the compressor can rise rapidly. A bursting disc would then rupture to relieve the pressure and prevent damage to the compressor itself.
- **Sudden System Surge:** In rare cases, a sudden surge in demand for compressed air can cause a temporary pressure spike within the system. A bursting disc can act as a safety measure by rupturing and releasing some of the pressure to prevent system overpressurization.

(b) Location of Devices:

(i) Fusible Plug:

The fusible plug is typically located on the discharge side of the compressor, near the cylinder head or intercooler outlet. This placement allows it to respond quickly to temperature changes within the compressor itself.

(ii) Bursting Disc:

The bursting disc can be located in several places within the compressed air system, depending on the specific application and potential failure points. Here are some common locations:

- **Aftercooler Outlet:** Protects the aftercooler and downstream piping from excessive pressure due to a blocked discharge line or malfunctioning pressure regulator.
- **Compressor Discharge Line:** Provides a safety measure close to the pressure source in case of a sudden pressure surge or regulator failure.
- **Air Receiver:** May be used as an additional safety measure on the air receiver itself, protecting it from overpressurization.

Note: The specific placement of these devices may vary depending on the manufacturer's recommendations, local regulations, and the specific design of the compressed air system.

Consulting the manufacturer's documentation and relevant safety codes is crucial for ensuring proper placement and operation of these safety devices.

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Nov 2020

4. With reference to hydraulic systems:

(a) state THREE possible contaminations; (3)

(b) state possible causes of the contaminations stated in part (a). (3)

(c) explain how the contaminants stated in part (a) are prevented from affecting the system. (4)

Question 4. Well answered by most.

Hydraulic System Contamination and Prevention

Hydraulic systems rely on clean fluid for efficient and reliable operation. However, contamination can pose a significant threat. Here's a breakdown of three common contaminants and methods to prevent them:

(a) Three Possible Contaminations:

1. **Dirt and Foreign Particles:** These can include dust, sand, metal shavings, or any foreign debris that enters the system.
2. **Air:** Air entering the hydraulic system can cause problems like spongy operation, cavitation, and increased noise.
3. **Water:** Water contamination can lead to corrosion, hydrolysis (breakdown of hydraulic fluid), and freezing in cold environments.

(b) Possible Causes of Contamination:

- **Dirt and Foreign Particles:**
  - Contaminated new fluid: Using dirty or unfiltered hydraulic fluid can introduce contaminants.
  - Improper maintenance: Failure to replace filters or maintain proper fluid cleanliness allows dirt to accumulate.
  - External leaks: Leaks in the system can allow dirt and debris from the surrounding environment to enter.
- **Air:**
  - Leaking connections: Improperly sealed connections, loose fittings, or worn seals can allow air to be sucked into the system.
  - Low fluid level: If the hydraulic fluid reservoir is not properly filled, air can be drawn in as the pump operates.
  - Air entrainment during refilling: Introducing new hydraulic fluid too quickly can trap air bubbles within the system.
- **Water:**

- Condensation: Moisture in the air can condense within the system, especially in environments with significant temperature fluctuations.
- Contaminated new fluid: Using hydraulic fluid that already contains water can introduce contamination.
- Coolant leaks: In systems where the hydraulic fluid is cooled by a separate water-based system, a leak in the heat exchanger can allow water to mix with the hydraulic fluid.

(c) Preventing Contamination in Hydraulic Systems:

Several methods can be implemented to prevent contamination and protect your hydraulic system:

- **High-Quality Filtration:** Using high-quality filters at the reservoir inlet, return line, and potentially within critical components like valves helps trap dirt and foreign particles before they can enter the system. Regularly changing filters is crucial.
- **Proper Maintenance:** A well-maintained system is less prone to contamination. This includes regular inspections for leaks, timely replacement of worn seals and components, and maintaining proper fluid cleanliness levels through fluid analysis and changes when necessary.
- **Sealing and Breather Selection:** Using proper seals and breathers on components can prevent leaks and minimize air intake from the environment. Breathers should be equipped with filters to prevent dust ingress.
- **Reservoir Design:** Reservoirs with proper baffling and breathers help minimize air intake and allow for settling of contaminants at the bottom, where they can be drained periodically.
- **Fluid Management:** Using clean, high-quality hydraulic fluid and following proper storage and handling practices minimizes contamination risks.
- **Closed-Loop Systems:** Where feasible, designing closed-loop systems can significantly reduce the risk of contamination from external sources.

By implementing these preventative measures, you can maintain the cleanliness and integrity of your hydraulic system, ensuring reliable operation and extended lifespan for your equipment.

020

Nov 2020

5. Describe, with the aid of a block diagram, the operation of an automatic steering system, including auto-pilot and valve operated steering gear. (10)

Question 5. Very poor. Many do not understand the term 'block diagram', many simply sketch and describe a steering gear. Of those that try to describe the basics of control, they appear to believe that the rudder angle is fed back to the auto-pilot – i.e that the rudder has a set angle required to maintain the vessel on course rather than the rudder moving from centre to return the vessel to the set course. Rudder feedback is used to limit the rate of change of course but none mention this. Several make no attempt.

Block Diagram of an Automatic Steering System with Auto-Pilot and Valve Operated Steering Gear

An automatic steering system, also known as autopilot, utilizes various components to maintain a set course for a vessel. Here's a block diagram outlining its operation:

Blocks:

1. **Course Reference System (CRS):**
    - This block provides a reference for the desired course. It can be a:
        - **Gyrocompass:** Senses the vessel's heading based on Earth's rotation.
        - **GPS (Global Positioning System):** Provides highly accurate position information.
        - **Combination of both:** For enhanced accuracy and redundancy.
2. **Course Setter:**
    - This allows the operator to input the desired course (heading) for the autopilot to follow.
3. **Heading Sensor:**
    - Senses the vessel's actual heading information. This can be:
        - **Gyrocompass output** (if separate from CRS).
        - **GPS derived heading:** Utilizing position data and course over ground (COG).
4. **Autopilot Controller:**
    - This is the "brain" of the system. It compares the desired course (from CRS and Course Setter) with the actual heading (from Heading Sensor).
    - Based on the difference (course error), the controller calculates the necessary rudder adjustments to minimize the error and maintain the desired course.
    - Common control algorithms used include Proportional-Integral-Derivative (PID) control.
5. **Rudder Command Signal:**
    - The autopilot controller generates a control signal based on the calculated rudder adjustment. This signal can be:
        - **Electrical signal:** Sent to a servo motor driving a valve.
        - **Hydraulic signal:** Controls a pilot valve in a hydraulic system.
6. **Valve Operated Steering Gear:**
    - This block translates the control signal from the autopilot into physical movement of the rudder. It can be:
        - **Electro-hydraulic system:** An electric motor drives a pump that pressurizes hydraulic fluid. A servo valve, controlled by the autopilot's signal, directs the fluid flow to rams that move the rudder.
        - **Electro-pneumatic system:** A solenoid valve, controlled by the autopilot's electrical signal, directs compressed air to actuators that move the rudder.
7. **Feedback Loop:**
    - The actual rudder position (often sensed by a rudder angle sensor) can be fed back to the autopilot controller. This feedback helps to ensure accurate and precise rudder adjustments.

Overall Operation:

1. The operator sets the desired course using the Course Setter.
2. The CRS and Heading Sensor provide continuous information about the desired and actual headings, respectively.
3. The autopilot controller compares these headings and calculates the course error.
4. Based on the error, the controller generates a rudder command signal.
5. The valve-operated steering gear translates this signal into rudder movement.
6. (Optional) The actual rudder position is fed back to the controller for improved accuracy.

This continuous cycle of comparison, calculation, and adjustment allows the autopilot to maintain the set course automatically, reducing workload for the crew and improving navigational efficiency.

2020

Nov 2020

6. With reference to controllable pitch propellers:

(a) describe a mechanism that changes the pitch of the blades; (7)

(b) explain how the pitch of the blades is indicated. (3)

Question 6. Several answer this question by describing the whole system, the question just asks about the mechanism for changing the blade angle. Of those that describe the mechanism, most mention longitudinal movement and angular but none actually explain how longitudinal is changed to angular. Several make no attempt

Controllable Pitch Propeller Mechanisms and Indication

(a) Mechanism for Changing Blade Pitch:

Controllable pitch propellers (CPP) allow for adjusting the angle of the propeller blades while the engine is running. Here's a breakdown of a typical mechanism for changing blade pitch:

Components:

- **Hub:** The central part of the propeller that houses the pitch change mechanism.
- **Blades:** Hydrofoils that rotate and generate thrust. They can pivot within the hub to change their pitch angle.
- **Pitch Change Rod:** A shaft or linkage that connects the blade root to the pitch change mechanism within the hub.
- **Pitch Control Mechanism:** This mechanism is located inside the hub and can be:
  - **Hydraulic System (Most Common):** Uses pressurized hydraulic fluid to actuate pistons or cylinders that push or pull on the pitch change rods, adjusting the blade angles.
  - **Electric System (Less Common):** Uses electric motors to drive gear mechanisms that rotate the pitch change rods.

Operation:

1. **Command Signal:** The operator on the bridge sends a signal (electrical or mechanical) to the pitch control system. This signal indicates the desired blade pitch angle.
2. **Hydraulic or Electric Actuation:** Depending on the system type, the signal activates either a hydraulic pump or an electric motor within the pitch control mechanism.
3. **Hydraulic Fluid Flow (Hydraulic System):** In a hydraulic system, pressurized fluid is directed to specific chambers within pistons or cylinders based on the desired pitch change.
4. **Rod Movement:** The pressurized fluid pushes or pulls on pistons or cylinders, which in turn transmit the force through the pitch change rods.

5. **Blade Pitch Adjustment:** The pitch change rods are connected to the blade roots, and their movement causes the blades to pivot within the hub, adjusting their pitch angle.
6. **Electric Motor and Gear Mechanism (Electric System):** In an electric system, the activated motor drives gears that rotate the pitch change rods, achieving the desired blade pitch adjustment.

(b) Pitch Blade Indication:

The operator needs to know the actual pitch angle of the propeller blades for optimal performance and control. Here are two common methods for indicating blade pitch:

- **Mechanical Pitch Indicator:** This is a dial gauge located near the bridge control system. It's connected to the pitch control mechanism via linkages or cables. As the blades move, the linkages rotate the gauge, displaying the actual pitch angle on the dial.
- **Electronic Pitch Indicator:** This is a more modern system that uses sensors within the hub to measure the actual blade angle. The sensor data is transmitted electronically to a display on the bridge, providing a real-time and accurate indication of the blade pitch.

Additional Considerations:

- Safety features like blade position interlocks might be incorporated to prevent unintended blade movement during engine start-up or shutdown.
- Redundant systems (e.g., backup pumps) could be included in critical applications to ensure continued pitch control even in case of a malfunction.

By employing mechanisms like hydraulics or electrics, controllable pitch propellers offer precise control over blade pitch, enhancing vessel maneuverability, efficiency, and performance across various operational scenarios. The use of either mechanical or electronic pitch indicators ensures the operator has accurate information about the actual blade angle for optimal control.

2020

Nov 2020

7. With reference to intermediate shaft bearings of the roller type, describe, with the aid of a sketch, EACH of the following:

(a) how some angular misalignment of the shaft is accommodated; (5)

(b) how longitudinal movement of the shaft is accommodated. (5)

Question 7. Most are OK with angular movement but struggle to explain how longitudinal movement is allowed. Some explain thrust bearings, several make no attempt.

Intermediate Shaft Roller Bearings: Accommodation of Misalignment

(a) Accommodation of Angular Misalignment:

Intermediate shaft roller bearings, while designed for optimal performance with minimal misalignment, can accommodate some degree of angular misalignment between the shaft and the bearing housing. Here are two main types of roller bearings that offer some tolerance for angular misalignment:

- **Cylindrical Roller Bearings:** These bearings have cylindrical rollers that line up parallel to the shaft axis. They can tolerate a small amount of angular misalignment (typically within a few degrees) by allowing the rollers to tilt slightly within the bearing cage. This tilting action helps distribute the load more evenly across the rollers even with minor shaft misalignment.
- **Spherical Roller Bearings:** These bearings incorporate rollers that are shaped like a barrel and rest on a concave bearing race. This design allows for a larger degree of angular misalignment (up to around 15 degrees) compared to cylindrical roller bearings. The spherical shape of the rollers and the conforming raceway enable them to self-align to accommodate slight shaft angularity.

It's important to note that exceeding the recommended angular misalignment limits for these bearings can lead to increased wear, reduced bearing life, and potential damage. Maintaining proper shaft alignment is crucial for optimal bearing performance and longevity.

(b) Accommodation of Longitudinal Movement of the Shaft:

Intermediate shaft roller bearings are typically not designed to accommodate significant longitudinal (axial) movement of the shaft. Here's why:

- **Roller Design:** Roller bearings rely on line contact between the rollers and the races for smooth rolling and load-carrying capacity. This design is optimized for radial loads (perpendicular to the shaft axis). Axial movement could cause the rollers to rub against the ends of the races, increasing friction and potentially damaging the bearing.
- **Internal Clearance:** Roller bearings typically have a specific internal clearance between the rollers and the races. This clearance allows for proper lubrication flow and heat dissipation. Excessive axial movement could reduce or eliminate this clearance, leading to binding, increased friction, and bearing failure.

Accommodation Methods (Limited Cases):

In some specific applications, intermediate shaft roller bearing arrangements might incorporate additional features to accommodate limited axial movement:

- **Thrust Bearings:** In some designs, a separate thrust bearing (typically a ball or roller thrust bearing) might be installed alongside the roller bearing. This dedicated thrust bearing takes on the responsibility of managing axial loads and allows the roller bearing to focus on radial loads.
- **Specialized Roller Bearing Designs:** Some manufacturers offer specialized roller bearing designs with features like crowned rollers or tapered flanges that can tolerate a small degree of axial movement. These bearings are typically used in specific applications where limited axial movement is unavoidable.

In conclusion, while intermediate shaft roller bearings offer some tolerance for angular misalignment, they are generally not designed for significant longitudinal shaft movement. Proper shaft design and alignment practices are crucial to minimize axial loads and ensure optimal performance and longevity of these bearings.

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Nov 2020

Nov 2020

8. Sketch an arrangement for the aft seal of an oil lubricated stern tube bearing. (10)

Question 8. Either well answered or no idea – drawing a sort of stern seal oil system. Several make no attempt.

Here's a breakdown of a typical arrangement for the aft seal of an oil-lubricated stern tube bearing:

Components:

1. **Housing:** A robust housing is securely attached to the stern tube bossing of the vessel. This housing provides a secure enclosure for the sealing elements.
2. **Liner:** This is a wear ring made from a low-friction material (often white metal or a suitable plastic) that is fixed onto the propeller hub. The sealing elements make contact with the liner to create a tight seal.
3. **Primary Seal:** This is the first line of defense against seawater ingress. There are two main options:
   - **Lip seal:** A spring-loaded lip makes contact with the liner to create a sealing effect.
   - **Mechanical seal:** This utilizes rotating faces and a lubricating film to achieve a tight seal.
4. **Secondary Seal:** This provides additional protection against seawater ingress. It can be similar in design to the primary seal or might utilize a different sealing mechanism like a labyrinth seal with a series of grooves and clearances to impede water ingress.
5. **Oil Buffer Chamber:** This is a chamber within the aft seal housing located between the primary and secondary seals. The chamber is filled with oil at a pressure slightly higher than the seawater pressure outside. This creates a pressure barrier that helps prevent seawater from entering the stern tube.
6. **Drain Line:** A drain line allows any leakage from the primary or secondary seals to be collected and returned to the oil lubrication system. This prevents oil accumulation within the aft seal housing.
7. **Ventilation (Optional):** In some designs, a ventilation system might be incorporated to remove any moisture or vapors that could accumulate within the aft seal housing.

Operation:

As the propeller shaft rotates, the liner rotates with it. The primary and secondary seals make contact with the liner, creating a barrier against seawater. The oil buffer chamber maintains a slight positive pressure to further prevent seawater intrusion. Any leakage past the primary seal is collected and drained back to the oil system.

Importance of Maintenance:

Regular inspection and maintenance of the aft seal arrangement are crucial. Monitoring oil pressure in the buffer chamber, checking for leaks, and inspecting the condition of the liner and seals are essential to ensure continued functionality and prevent potential seawater contamination of the lubricating oil or oil leakage into the environment.

Here are some additional points to consider:

- Some designs might incorporate additional features like wear indicators or monitoring systems to track seal performance and alert for potential issues.
- The specific arrangement and components might vary depending on the size and design of the vessel and the stern tube bearing system. Always refer to the manufacturer's instructions for specific details and maintenance procedures.

v 2020

Nov 2020

9. (a) State FIVE devices fitted to a main distribution switchboard in order to protect a.c. generators that can be operated in single or parallel mode. (5)

(b) Explain why EACH device stated is needed. (5)

Question 9. The question asks about devices for protection of generators, many include pref trip and other devices that are for protection of distribution. Most, when answering about the reason for a device, simply state what it does – i.e over-current protection protects against overcurrent. The question is asking for the reason for the device – i.e what would overcurrent do to the generator.

Protection Devices for A.C. Generators in a Main Switchboard (Single/Parallel Operation)

(a) Five Key Devices:

A main distribution switchboard for protecting AC generators, especially those capable of single or parallel operation, will typically include the following five devices:

1. **Circuit Breaker:** The main circuit breaker protects the generator from overload currents. It trips and isolates the generator from the distribution system if the current exceeds a pre-set safe limit.
2. **Undervoltage Protection Relay:** This relay monitors the generator's output voltage. If the voltage falls below a minimum acceptable level, the relay trips and disconnects the generator from the system. This prevents the generator from operating under abnormal conditions that could damage itself or connected equipment.
3. **Overvoltage Protection Relay:** Conversely, this relay protects against excessively high voltage output from the generator. If the voltage exceeds a pre-set limit, the relay trips, disconnecting the generator to prevent damage to itself or downstream equipment.
4. **Synchronizing System (for Parallel Operation):** When operating generators in parallel, a synchronizing system is essential. This system ensures the generators are synchronized in terms of frequency, voltage, and phase before paralleling. This prevents damaging surges and ensures smooth load sharing between generators.
5. **Reverse Power Protection Relay (Optional):** In some installations, a reverse power protection relay might be included. This relay protects the generator from motoring (acting as a

motor instead of a generator) if the prime mover fails or the connected load becomes a source of power feeding back into the generator.

(b) Explanation for Each Device:

1. **Circuit Breaker:** Protects the generator from damage caused by excessive currents due to overloads or faults on the distribution system.
2. **Undervoltage Protection:** Prevents the generator from operating under abnormal conditions that could lead to internal damage or instability. It also safeguards connected equipment from potentially harmful low voltage situations.
3. **Overvoltage Protection:** Protects the generator and downstream equipment from damage caused by excessively high voltage output. This can occur due to malfunctioning voltage regulation or other internal issues.
4. **Synchronizing System:** Ensures safe and stable parallel operation of generators by synchronizing their frequency, voltage, and phase. This prevents damaging current surges and allows for efficient load sharing.
5. **Reverse Power Protection (Optional):** Protects the generator from potentially damaging reverse power flow if the prime mover fails or if the connected load feeds power back into the generator. This can occur in some system configurations.

v 2020

Nov 2020

10. (a) Explain the term *single phasing*. (2)

(b) State the effects on a motor of single phasing. (6)

(c) State how single phasing may be protected against in the motor starter circuit. (2)

Question 10. Reasonably well answered by most, nearly all struggle with protection should single phasing occur.

Single Phasing in Electric Motors:

(a) Definition:

Single phasing refers to a condition in a three-phase AC power supply system where one of the three phases is interrupted or loses voltage. This can occur due to several reasons, such as a blown fuse, open circuit breaker, or a loose connection on one of the phases.

In a healthy three-phase system, the three voltage phases are balanced and reach their peak values at different times within the AC cycle. This balanced system allows three-phase motors to operate efficiently and smoothly.

(b) Effects on a Motor:

Single phasing can have several detrimental effects on a three-phase induction motor:

- **Reduced Torque and Speed:** With only two phases supplying power, the rotating magnetic field becomes unbalanced and weaker. This leads to a decrease in the motor's torque output and a potential reduction in speed.
- **Increased Current:** The remaining two phases have to carry more current to compensate for the missing phase. This can lead to overheating of the motor windings and potential damage to the motor's insulation.
- **Vibrations and Noise:** The unbalanced magnetic field can cause the motor to vibrate excessively and generate increased noise during operation.
- **Potential for Motor Damage:** Prolonged operation under single phase conditions can lead to permanent damage to the motor windings due to overheating and excessive currents.

(c) Protection Against Single Phasing:

Several methods can be employed in the motor starter circuit to protect against single phasing:

- **Single Phasing Relays:** These dedicated relays monitor the voltage and current in each phase. If they detect an imbalance or loss of voltage in one phase, they trip the motor starter circuit and disconnect the motor from the power supply.
- **Motor Overload Protection:** While not specifically designed for single phasing, overload protection devices like thermal overload relays can trip the motor starter if the excessive current draw caused by single phasing leads to overheating. However, this might not be a fast enough response to prevent potential damage.
- **Phase Sequence Monitors:** These devices can be used to ensure the correct phase sequence of the incoming power supply. Incorrect phase sequence can also lead to problems similar to single phasing.

Using a combination of these protection methods can help safeguard your three-phase induction motor from the damaging effects of single phasing. Always refer to the motor manufacturer's recommendations and electrical codes for the most appropriate protection scheme for your specific application.